ITEM NO. 9
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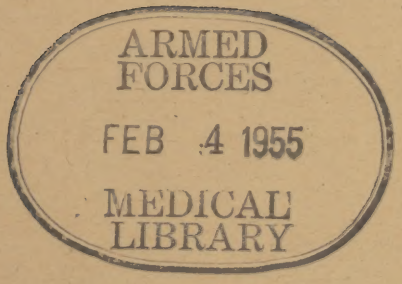
GERMAN X-RAY AND ELECTRO-MEDICAL INDUSTRY



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COMBINED INTELLIGENCE OBJECTIVES
SUB - COMMITTEE

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INVESTIGATION OF THE GERMAN X-RAY & ELECTRO-MEDICAL INDUSTRY

Reported By

CAPERTON B. HORSLEY, U.S. Civilian

CIOS Target Numbers 9/37, 9/37 a, 9/221
(9) Physical & Optical Instruments & Devices

COMBINED INTELLIGENCE OBJECTIVES SUB-COMMITTEE
G-2 Division, SHAEF (Rear) APO 413

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Personnel of Team

CAPERTON B. HORSLEY, U. S. CIVILIAN

GENERAL DESCRIPTION:

Comment:

This report is based on information obtained from an inspection of the Siemens-Reiniger plants in Rudolstadt and Erlangen, from 14 May 1945 to 19 May 1945, as well as a previous inspection of the industrial X-ray installations at the Metallgussgesellschaft plant, near Leipzig, on 10 May, 1945.

Siemens-Reiniger-Werke A/G, Rudolstadt:

This organization is the largest European manufacturer of X-ray tubes and valve tubes for X-ray equipment.

As of 1 March, 1945, they had 550 employees. About 50 were engaged in the production of fluoroscopic and intensifying screens and the like, and 100 were producing small amplifying and detector tubes, etc., as part of their "war work" program. The remaining 400 were involved in the production of X-ray tubes and high voltage valve tubes for X-ray equipment.

The plant is well equipped and has not been damaged. This organization does its own research and engineering work for all of its "X-ray" products.

The following persons, all of whom were cooperative, were interviewed at this plant:

Dr. Albrecht Wölfel, Chief Director

Dr. Theodor Zimmer, Head of Physical Research Laboratory and X-Ray Tube Development

Dr. Josef Hartmann, Research and Production Manager of Chemical Department

Mr. Walter Döhler, Business Manager

Mr. Hans Frank, Sales Manager

Dr. Werner Jacoby (Dr. Jacoby was recently evacuated from Vienna, where he had been in charge of research and development for all Siemens and Halske vacuum tubes except tubes for X-ray equipment. Siemens-Reiniger is only one of the many manufacturing organizations owned or controlled by Siemens and Halske.

The following figures will indicate the monthly production of this plant as of March of this year:

X-Ray Tubes.....800
Valve Tubes (for X-ray equipment).....200
Intensifying Screens.....1,100 sq.ft.
Fluoroscopic Screens.....120 sq.ft.

Of "Non X-Ray Products":
Amplifying (Repeater) Tubes..... 6,000
Small Gas Filled "Detector" Tubes....20,000
Gas Filled Surge Protecting Tubes
For Communication Lines.....20,000

Siemens-Reiniger-Werke A/G Erlangen:

This organization designs and manufactures X-ray apparatus and other electro-medical equipment. Tubes are supplied to Erlangen by the Rudolstadt plant.

During the past several years this plant has manufactured, but not designed, some assemblies and parts for aircraft radio, instrument, and control equipment.

The plant is well equipped, and although there had been some damage by looting, there had been no bomb damage.

Up to the time of occupation, this plant had about 3000 employees, approximately one third of whom were working on "war work" (aircraft radio assem-

blies, etc.), another third on X-ray equipment, and the remainder on other electro-medical equipment.

This plant has a total floor area of approximately 400,000 square feet. As of the first of this year, the total monthly payroll was about 450,000 marks.

The following persons, all of whom were cooperative, were interviewed at this plant:

Dr. Max F. Anderlohr, Chief Director of both Erlangen & Rudolstadt plants

Dr. Johannes Pätzold, Chief of Research and Development Laboratories

Mr. Kurt Bischoff, Chief of X-Ray Development (Under Pätzold)

Dr. Walter Hoffman, Chief of Patent Department of both Erlangen and Rudolstadt plants

Mr. Karl Silbermann, Liaison Officer on X-ray and valve tubes between Erlangen & Rudolstadt plants

Dr. Theo. Sehmer, Sales and Service Manager

Dr. Karl Lasser, Technical Director of Sales and Service

Albert Marcus, M.D., Specialist on "Electrical Medicine"

(Sehmer, Lasser, & Marcus were recently evacuated from the Siemens-Reiniger Berlin Office)

The average production of this plant during the past year is indicated below:

A. <u>Transformer & Control Units for Therapy</u>:

1200 Kv.P.-5 Ma., per year..... 1

400 Kv.P.-5 Ma., per year..... 3

200 Kv.P.-30 Ma., per month..... 12

120 Kv.P.-8 Ma., per month..... 3

60 Kv.P.-5 to 8 Ma., for Contact Therapy, per month..... 3

B. Transformer & Control Units Primarily for Radiography & Fluoroscopy, but Occasionally Used for Superficial Therapy:

100 Kv.-2000 Ma. (Condenser Discharge), per month..... 2

100 Kv.-1000 Ma. (3 Phase), per month... 3

120 Kv.-800 Ma. (Full Wave), per month.. 4

120 Kv.-400 Ma. (Full Wave), per month..16

120 Kv.-200 Ma. (Full Wave), per month..11

120 Kv.-80 Ma. (Half Wave), per month...23

90 Kv.-50 Ma. (Self-Rectified), per mo.20

75 Kv.-25 Ma. (Self-Ractified), per mo.15

60 Kv.-15 Ma. (Self-Rectified, "Sphere", Including Dental) per month.....150

C. Other X-Ray or Electro-Medical Units:

Photofluorographic Units, per month..... 8

Metal Searcher (Production started 1942. About 1000 units in all have been produced for the Army) per month.....30

Electric Shock Treatment Unit (200 total since 1942) per month..... 7

6 Meter H.F. Unit (12,000 total since 1933) per month.....150

H.F. Surgical Knife (all models) per month..... 15

1 Meter H.F. Unit (10 were made in 1937 & 1938. None since because magnetrons could not be obtained)..... 0

Cassettes (all sizes), per month.....800

Bucky-Potter Diaphragms, (moving grids) per month..... 75

Bucky-Potter Diaphragms (fixed grids) per month.....180

Motor-Pantostat (Universal Electro-Medical Unit) per month..... 35

Mechanical Dental Machines, per month.120

Note: Much additional X-ray and electro-medical equipment was made at this plant, such as tube stands, tilting tables, vertical fluoroscopes, stereoscopes, etc.

Metallgussgesellschaft, Bolitz-Ehrenberg, (Leipzig):

This plant produced light metal castings for aircraft engines, including castings for the Junkers 109.004 Jet Engine. As of the first of this year this plant had 3500 employees, and produced about 400 tons of aluminum and magnesium alloy castings per month.

Throughout the foundry there were ten separate X-ray examination locations. Although much of the X-ray equipment had been removed or destroyed by the management, the following observations may be of interest:

1. It seemed that each location had been composed of two or more radiographic installations. Several fluoroscopic installations were found.

2. In all, it appeared that from twenty to twenty-five radiographic installations, from three to five fluoroscopic installations, and from five to ten dark room installations had been in use.

3. All of the equipment examined had been manufactured by Seifert, In Hamburg, and used A.E.G. end-ground, magnetically focused tubes, some of which were rated at 150 Kv., and some at 200 Kv.

4. We were told that all portions of every casting were examined either radiographically or fluoroscopically, and that the average figure for rejects was about 25%.

German X-Ray Industry:

Following is a list of most of the "X-Ray" manufacturers in Germany, indicating the approximate number of persons employed in the production of X-Ray tubes and equipment, as of a few months ago:

1. Siemens-Reiniger-Werke A/G, Rudolstadt, X-Ray Tubes & Screens.....450

2. Siemens-Reiniger-Werke A/G Erlangen, X-Ray Equipment.....1000

3. C.H.F. Müller, Hamburg-Fühlsbuttel, X-Ray Tubes & Equipment.....300
   (Dr. Ritz, Chief Director; Dr. Fehr, Head of Physical Research Laboratory; Dr. Müller, Head of X-Ray Tube Laboratory; Mr. Daumann, Production Manager).

4. A.E.G. Röhrenwerk Oberspree, Berlin, X-Ray Tubes.....200
   (Dr. Traub, Director of X-Ray Tube Production)

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5. Radiologie Röntgenröhrenfabrik, A/G. Recently moved from Berlin to Gera
   Valve Tubes for X-Ray Equipment.....40
   (Mr. Gloger, Director)

6. Otto Kiesewetter, Rudolstadt
   Valve Tubes for X-Ray Equipment.....10

7. Koch and Sterzel, Dresden
   X-Ray Equipment.....250

8. Sanitas, Berlin, Karlstrasse
   X-Ray Tubes & Equipment.....300

9. Seifert, Hamburg, Herman-Behn-Weg 7-11
   X-Ray Equipment for Industrial Radiography and Fluoroscopy.....250

10. Ritter, Freiburg im Breisgau
    Dental X-Ray Equipment.....550

11. Marhold, Vienna
    X-Ray Equipment.....100

12. Siemens and Halske A/G, Berlin
    X-Ray Equipment for Industrial Radiographic, Fluoroscopic, and Diffraction work.....300?
    (Produced "several hundred" complete units per year)

    Total.....3750

The three "most important" X-ray physicists in Germany were reported to be:

1. Prof. Behnken, Physikalisch Technische Reichsanstalt, Berlin. (Dosimetry)

2. Prof. Friedrich, Institute für Strahlenkunde, Berlin. (Radiation Research)

3. Prof. Grebe, Bonn. (Cloud Chamber work)

The most important radiologists and X-ray clinics in Germany were reported to be:

1. Dr. Zimmer & Prof. Timofeef-Ressovsky, Kaiser Wilhelm Institute for Brain Research, Berlin-Buch. (Work on border line of X-ray physics and biology).

2. Prof. Langendorf, Radiological Institute, Freiburg im Brsisgau (X-ray physics and biology).

3. Charite Krankenhaus, Berlin (Low voltage therapy).

4. St. Georg Hospital, Hamburg (High voltage therapy and diagnostic work).

5. Stadtkrankenhaus, Frankfurt am Main (Diagnostic and therapy).

6. Frauenklinik, Erlangen (Therapy, Prof. Wintz).

SOURCES OF SUPPLY:

Following is a list of the German sources of supply for most of the materials and products required for the production of X-ray tubes and equipment:

1. Tantalum:
Siemens & Halske, Berlin, the only producers of tantalum in Europe.

2. Beryllium:
Heraeus Vacuum Schmelze, Hanau (near Frankfurt am Main). (This plant was owned by Siemens. It has now been destroyed, and the two chief directors killed).

3. Tungsten:
   Osram, Berlin. Also Deutsche Edelstahl Werke, Berlin, factory in Reuthe in Tyrol, Austria.

4. Molybdenum:
   Same as above.

5. Glass:
   Schott und Genossen, Jena. Also, Glaswerk Fischer, Ilmenau. Also Osram, Weisswasser (near Berlin).

6. Oxygen free copper:
   Siemens & Halske, Berlin and Vienna. Also, oxygen free copper sheet from Heraeus in Hanau.

7. Transformer Oil:
   Rhenania-Ossag, Hamburg

8. High Tension Cable:
   Siemens-Schuckertwerke Kabel-Werk, Gartenfeld bei Siemensstadt, Berlin (Made flexible cable up to 300 Kv.P., D.C., between the center conductors and the ground sheath).

TECHNICAL DEVELOPMENTS:

Vacuum Tubes:

Following is a summary of the most apparent developments, trends, and practices, in the design and construction of X-ray tubes and valve tubes for X-ray equipment.

1. End ground tubes with long electron beam paths, with and without magnetic focusing, in the range of from 60 to 200 Kv. All of the tubes found in Seifert radiographic or fluoroscopic industrial equipment were end ground, magnetically focused, A.E.G. tubes Siemens, in Rudolstadt, were making a line of orifical cavity contact therapy tubes.

It is understood that some of these orificial cavity tubes required magnet focusing, and some did not.

2. Very effective use of hooded anode construction in all X-ray tubes examined. By thus preventing secondary electrons from accumulating on the inner glass walls, and by effective construction and processing methods, Siemens has succeeded in producing some types that are appreciably smaller in size than tubes made in the U.S. having equivalent ratings. This is particularly apparent in their 300 Kv.P., 30 Ma. tube. Incidentally, this 300 Kv.P. tube has a heavy copper-tungsten hooded anode which reduces the external X-ray shielding required from 8 mm. to 4 mm.

3. A new process for coating steel balls with graphite for use in rotating target tubes. This process was reported to provide a longer life than the previously used process for coating steel balls with graphite.

4. The use of thoriated tungsten (2% thorium oxide) for the filaments of a few experimental high voltage valve tubes, thus reducing the filament wattage required, for the same emmission, to about 15%. Because of the processing difficulties involved in manufacturing high voltage valve tubes with thoriated tungsten filaments, most of their valve tubes were still being produced with pure tungsten filaments. The maximum inverse voltage on these thoriated tungsten tubes was 120 Kv. A longer than average life was expected.

5. The frequent use of columbium (niobium) in place of tantalum in X-ray and valve tubes. In Germany columbium was cheaper than tantalum, as it was a "by-product" of their tantalum refining process.

6. The construction of an end ground tube with a 30 cm. diameter focal spot for superficial therapy at about 100 Kv., or lower.

Note: It might be mentioned that for a number of years they have been producing a comparatively small (about 4 ft. long) single section 600 Kv.P. X-ray tube, air insulated at atmospheric pressure.

X-Ray Equipment:

The two particularly outstanding X-ray equipment developments seemed to be the exceedingly well worked out use of thick sections of built up paper in connection with the construction of high tension coils, and the development of unusually high voltage flexible cables.

Generally speaking, the practice at Siemens was to depend on paper instead of oil for high tension insulation, the oil being used primarily to impregnate the paper, prevent the absorption of moisture, and provide cooling.

The unusually high voltage flexible cables permitted the use of flexibly connected end ground tube heads at 200 Kv.P. and higher. One reasonably flexible cable, about 2½ inches in diameter, could be operated continuously at 300 Kv.P., D.C., between the center conductors and the outside ground sheath. This cable made use of two concentric semi-conducting paths to aid in equalizing the potential gradient.

Siemens, at Erlangen, had recently developed, but not put into production, an automatic system for use with photofluorography. This system automatically compensated for variations in line voltage, tube emmission, and chest thickness and density, making use of a specially constructed ionization chamber.

Siemens had also developed, but not yet put into production, a particularly compact 4 valve, oil immersed, transformer and control unit for 100 Kv. and 400 Ma.

During the past several years Siemens had developed and put into production an unusually light weight 75 Kv.-25 Ma. transformer and tube head, a small army field unit for use with this head, and a new tube stand arrangement for their larger army field unit.

Work was being done by Zeiss at Jena on the development, for Siemens, of an improved optical system for photofluorographic work.

Other Electro-Medical Equipment:

Following is a list of the new electro-medical equipment that had recently been developed, or was being developed, by Siemens in Erlangen:

1. Supersonic frequency unit for the treatment of certain nerve conditions.

2. High frequency "metal searcher" unit for determining the location and position of a metal object to be removed from the body. It is thought that this unit may have certain advantages over the apparatus now being used in the U.S. for this purpose.

3. A "new and improved" unit for administering shock treatment for schizophrenia, etc.

New Techniques:

The following list summarizes the new techniques or trends reported or indicated:

1. Trend toward high milliamperage, up to 2000 Ma., for radiographic and photofluorographic work.

2. A trend toward the more frequent use of contact therapy, particularly because of the development of a number of end ground tubes for the body cavities.

3. The use of a large focal spot (30 cm. diameter) in order to eliminate cross firing, or changes in the tube position, for light therapy.

4. The more frequent use of heat, by high frequency, in combination with X-ray therapy for cancer. It was reported that an increase in the temperature increased the sensitivity of cancer cells but did not appreciably increase the sensitivity of normal cells. It was mentioned that this technique was "discovered" in 1929, but was not "proven" until some time in 1941.

5. New foreign metal object locating techniques.

6. New supersonic techniques for the treatment of certain nerve conditions.

7. New shock therapy techniques.

MISCELLANEOUS NOTES:

Following is a more or less random list of miscellaneous notes:

1. Resonant Transformers:
No resonant transformers have been made in production in Germany, but one, for 600 Kv., has been in use for demonstration at the University at Kiel.

2. Cold Cathode Tubes:
A 300 Kv., 1000 ampere (10^{-7} seconds) cold cathode tube was developed by Prof. Herz of Siemens and Halske in Berlin, and was used in Nürnberg for the industrial radio-

graphy of fast moving parts. Prof. Muehlenkfort has done work with this tube.

3. 10 Kv. Technique:
The lowest voltage X-ray work done in Germany was reported to be 10 Kv. for some skin therapy techniques.

4. Diffraction Tubes with Titanium Targets:
Two diffraction tubes with titanium targets were recently made by Siemens in Rudolstadt for Prof. Glocker, the German iron expert in the Kaiser Wilhelm Institute at Stuttgart.

5. Diffraction Tubes with Chromium Targets:
To make chromium targets Siemens electroplates chromium to a thickness of 1 mm. The chromium is then plated with copper and silver-soldered to the copper anode. Nevertheless, Siemens is still troubled by the cracking of chromium targets.

6. Transmission Targets:
For transmission targets (for industrial radiography) Siemens electroplates gold on copper. For 150 Kv. the gold is about .02 mm, the copper 1.5 mm thick.

7. Gem Coloring by Radiation:
Work was recently done in Germany on the coloring of precious stones by X-ray radiation. However, it was found that many gems reverted to their original color after prolonged exposure to sunlight.

8. Beryllium Windows:
No one in Germany has yet produced vacuum tight beryllium windows in production, but most of the German X-ray tubes have beryllium windows in their hooded anodes. For 10 Kv. work the radiation passes through .1 mm of beryllium and .06 mm of Lindemann glass. The beryllium used for windows is as pure as can be obtained, about 99.8% beryllium, .1% iron, most of the remaining .1%

being crucible material. Dr. Deisinger of Siemens, in Berlin, did a considerable amount of work in connection with increasing the purity of beryllium.

9. Platinum Glass:
Siemens used a special platinum glass with a decoloring agent for some of their low voltage air insulated tubes.

10. Glass to Metal Seals:
Only copper-glass seals were used on most Siemens tubes. Müller uses some "Kovar" seals with hard glass, and chrome-iron seals with soft glass. Most "electrical glass" was produced in Jena.

11. Industrial Radiography & Other Inspection Methods:
Most industrial radiographic units in Germany do not exceed 200 Kv., although a few 300 Kv. and some 400 Kv. industrial radiographic installations have been made. For steel thicker than 200 mm. radium (mesothorium) was used. Thick sections were also inspected with supersonic frequencies, generally using 20 to 30 thousand cycles, and never more than 100,000 cycles. In addition to magnetic arrangements for testing rails, the "iron-filings-in-oil-bath-photographic method" was also in general use in Germany for detecting surface or sub-surface flaws in castings or other metal parts.

12. Tantalum & Columbium:
All of the tantalum ore used in Germany originally came from Australia. About 1939 Dr. Kolligs, of Siemens and Halske in Berlin, developed an economical method for refining tantalum from the large amount of refuse that had accumulated from the previously used refining process. Because of this there was no shortage of tantalum in Germany. With this method columbium was also recovered as a by-product of the

tantalum refining process. Columbium was often used in place of tantalum, since it has many of the characteristics of tantalum and was considerably cheaper.

13. 300 KW. Broadcast Tube with Tantalum Emitter:
Siemens and Halske, in Berlin, produced a 300 Kw., water cooled broadcasting tube (for frequencies up to 300 megacycles) with a semi-indirectly heated tantalum emitter. The heater wattage was reported to be between 30 and 40 Kw.

14. Use of Tantalum & Columbium:
Siemens used tantalum or columbium in X-ray tubes, and also as valve tube anodes.

15. Magnetic Focusing:
For one of the Siemens diffraction tubes magnetic focusing was used to obtain an effective focal spot size of 1 mm. with a 6° target, at 45 Kv. and 20 Ma. Using magnetic focusing they have obtained effective focal spot sizes as small as .2 mm with constant potential on the focusing coil and across the tube. With this size focal spot the tube could be operated continuously at 1 Ma. and 50? Kv.

16. Electron Therapy:
Siemens at Erlangen had constructed two Betatrons (Electronen-Schleuder), one of which operated at 6 and the other at 7 million electron volts. They were planning the construction of a 15 million volt model. They reported that their particular interest in this development was to provide a means for experimental work with electron beam cancer therapy.

17. New Materials:
The only "new materials" Siemens reported using was a liquid for condensers having a high dielectric constant, from 80 to 120, known as "Condensa", manufac-

tured by Hescho, in Hermsdorf. This is possibly "titan-dioxyd." They also used a similar liquid known as "Frequenta" ("Steatit-Magnesia?") which was produced in Lauf, near Nurnberg.

APPENDIX: List of documents obtained:

Copies of the following documents have been forwarded to Washington. The originals have been turned over to Military Intelligence Research Section, 40 Hyde Park Gate, London, S.W.7. and may be borrowed by requesting documents registered as CIOS/MIRS/103.

1. Screens:
   Description of process for manufacturing fluoroscopic and intensifying screens.

2. X-Ray Tubes:
   Photographs of X-ray and valve tubes, and description of process for making "vacuum bearings."

3. X-Ray Equipment:
   Drawing of Siemens secondary coil assembly, description of oil processing methods, and Sales Bulletins describing recently produced equipment.

4. Other Electro-Medical Equipment:
   Technical descriptions and Sales Bulletins of Siemens supersonic shock therapy, and metal searching units.

5. Electro-Medical Techniques:
   "High Frequency" in Medicine, by Johannes Patzold (1943).

6. Patents:
   Copies of all Siemens-Reiniger patent application drawings from August 1938 to April 1945.

Wt. 19648, C. & R. Ltd.